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# Diagonal charge stripes giving a suppression of spectral weight at selected spots on the Fermi surface

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In our Letter[1] we have reported a direct evidence for charge stripes in diagonal direction in Bi2212. We have recorded the photointensity distribution in the $k$ space to probe the spectral weight within 50 $meV$ around the Fermi level. This Fermi surface image has been obtained by rotating the sample around its normal, while the detector is moved in previous $ARPES$ measurements for the similar information[2]. Our experimental set-up allows us to probe directly the Fermi surface anisotropy while in the other approach the effects of intrinsic anisotropy are mixed-up with variation of matrix element effects. The colinearity of the sample normal and the rotation axis is within $\pm 0.5°$, established by laser alignment and photoelectron diffraction of core levels. The Fermi surface image shows broken segment with hot spots (photointensity cusps of spectral weight) and missing parts (minimum of spectral weight) that indicate charge stripes in the $CuO_2$ plane. The clear experimental evidence for stripes is given by the large suppression (about 70%) of spectral weight at four points $P_n$ ($n$=1,2,3,4) on the Fermi surface in the first Brillouin zone. This suppression arises for coupling of electrons with a $1D$ charge density wave in the diagonal direction of wavevector $q \sim (0.4\pi, 0.4\pi)$ (see the white arrows in the upper panel of Fig. 1). This wavevector is two times the wavevector of $1D$ lattice fluctuations $Q \sim (0.2\pi, 0.2\pi)$ detected by anomalous x-ray diffraction and $EXAFS$[3]. Moreover the points $P_1, P_3 (P_2, P_4)$ are connected by the wavevector of the antiferromagnetic correlations $G(\pi, \pi)$ in the stripe direction, (see the blue arrows in Fig. 1) indicating the additional coupling of electrons with spin density waves.

Mesot et al.[4] report a one-electron band calculation of the Fermi surface that is in qualitative and quantitative disagreemnt with the experimental data. In their calculations they include the contributions of *umklapp* satellite bands displaced by $\pm Q$ wavevector perpendicular to $\Gamma - X$ (due to diffraction from the superstructure in the $Bi - O$ plane) and satellite *shadow* bands displaced by $G$ wavevector. This simple calculation reproduces some features of the experimental photointensity distribution, for example the suppression along the $\Gamma - Y$ direction due to matrix element effects, and the weak features due to *umklapp* satellites. The calculated image shows hot spots where the main, *umklapp* and *shadow* band are crossing. This calculation is unable to reproduce the missing parts on the main Fermi surface arising from the suppression of spectral weight (not to be confused with the temperature dependent opening of partial gaps). To make it more clear we show the photointensity higher than 50% of the maximum, in the first Brillouin zone, in the lower panel, together with the calculated curves for the main, *umklapp* and *shadow* bands. It is evident that the points $P_n$, where the large suppression of spectral weight occur, lie at the four crossing points of the main and the *shadow* bands. Moreover these points can be located at the crossing point of the main Fermi surface and the lines connecting the $M - M_1$ points. In fact the charge density wavevector $q(0.4\pi, 0.4\pi)$ shown in Fig. 1 gives the suppression of spectral weight along these lines. The calculation of Mesot et al. gives maxima at the points $P_n$ and is unable to account the main point of our work. To reproduce the observed experimental features one needs to make more sophisticated calculations as recently reported by Bansil et al[5] for angle scanning photoemission images including the superlattice of quantum stripes in the $CuO_2$ plane[3]. Coming to the point of new electronic states reported in ref.[6], the asymmetry of the $\Gamma - M$ and $\Gamma - M_1$ direction is an intrinsic effect and not due to sample misalignment. Unfortunately no systematic efforts were made to investigate the asymmetry along the two $Cu$-$O$-$Cu$ bond directions prior to our measurements. In fact, our recent $Cu$ $K$-edge x-ray absorption measurements[7] ensure that the asymmetry of the $\Gamma - M$ and $\Gamma - M_1$ directions is intrinsic of the $CuO_2$ plane. Moreover in Fig. 3 of ref.[6] it can be seen that the intensity of this band is about 33% of the main and it is clearly stronger than the intensity of the umklapp satellite (22%). In addition the overlapping of the two photointensity polar cuts in the two directions in that figure rule out directly the argument of suspected sample misalignment.

[1] N.L. Saini et al, Phys. Rev. Lett. 79, 3464 (1997).

[2] H. Ding et al, Nature 382, 51(1996).

[3] A. Bianconi et al. Phys. Rev. B 54, 4310 (1996); ibid. 54 12018 (1996)

[4] J. Mesot et al, cond-mat/ 9811027

[5] A. Bansil et al, Proc. of STRIPES 98 (J. Supercond.).

[6] N.L. Saini et al, Phys. Rev. B 57, R11101 (1998).

[7] N.L. Saini et al Proc. of STRIPES 98 (J. Supercond.).

FIGURE CAPTION

FIG.1 Plot of the experimental photointensity around the Fermi surface (upper) and the main Fermi surface in the first Brillouin zone after cutting off the low intensity features due to satellites (lower). The points $P_n$ of highest suppression of spectral weigth are indicated

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